SuperBaBar Physics Reach

1. UT sides
2. UT angles
3. Rare decays
4. Experimental issues

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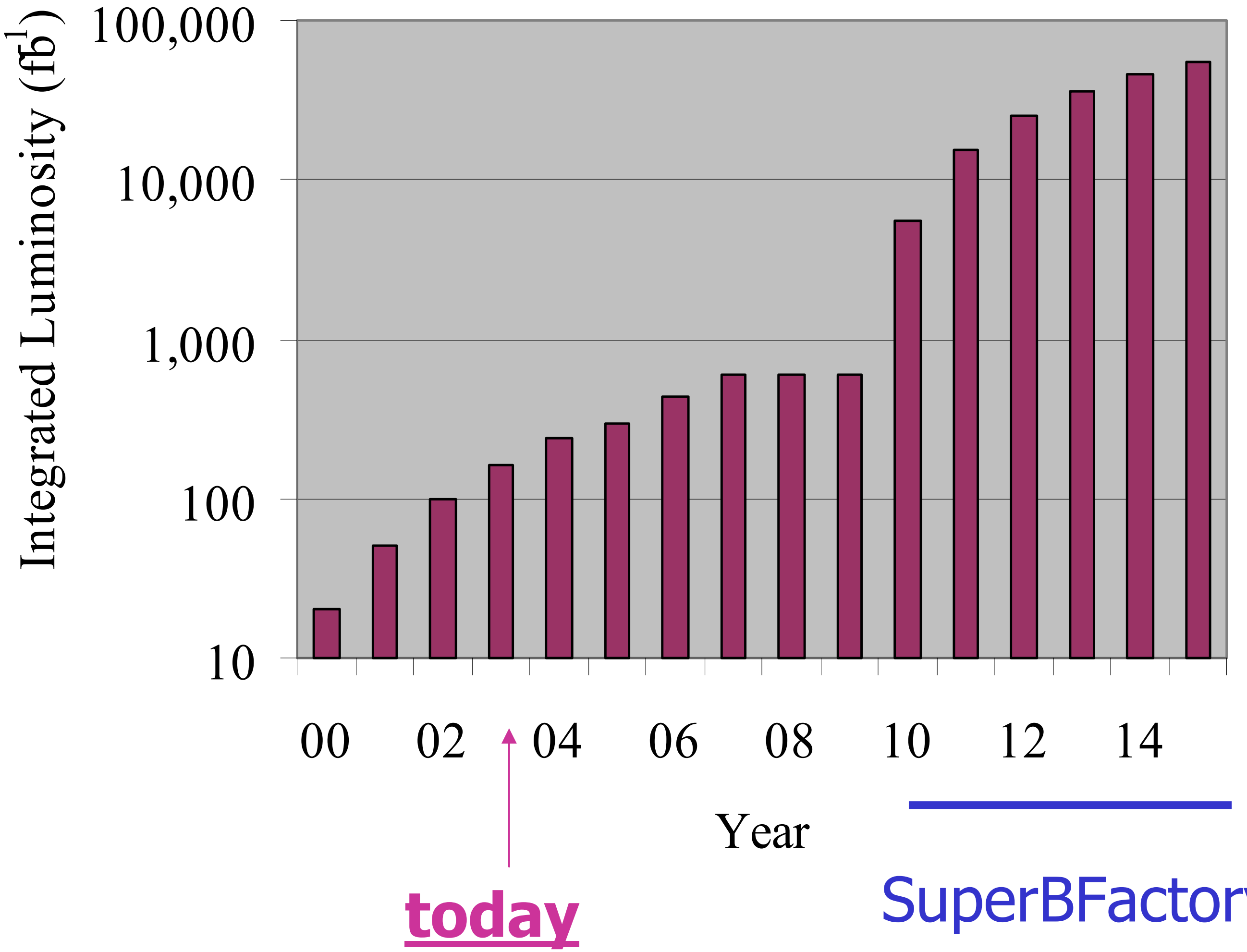
Disclaimer: Many studies are still in progress and some are missing
Numbers in this talk are not the final word!

SLAC B Factory Luminosity Projection

- Proposed profile: adiabatic PEP-II upgrades until ~2007
  Super B Factory with peak luminosity of 10^{36} cm^{-2} s^{-1} in $\geq$ 2010



BaBar expected integrated lumi ~0.6 ab^{-1} by 2007
$\Rightarrow$ 6 10^8 BB pairs

SuperBaBar integrated lumi
10 ab^{-1} per year
$\Rightarrow$ 10^{10} BB pairs/yr
~100 x BaBar in 5 years

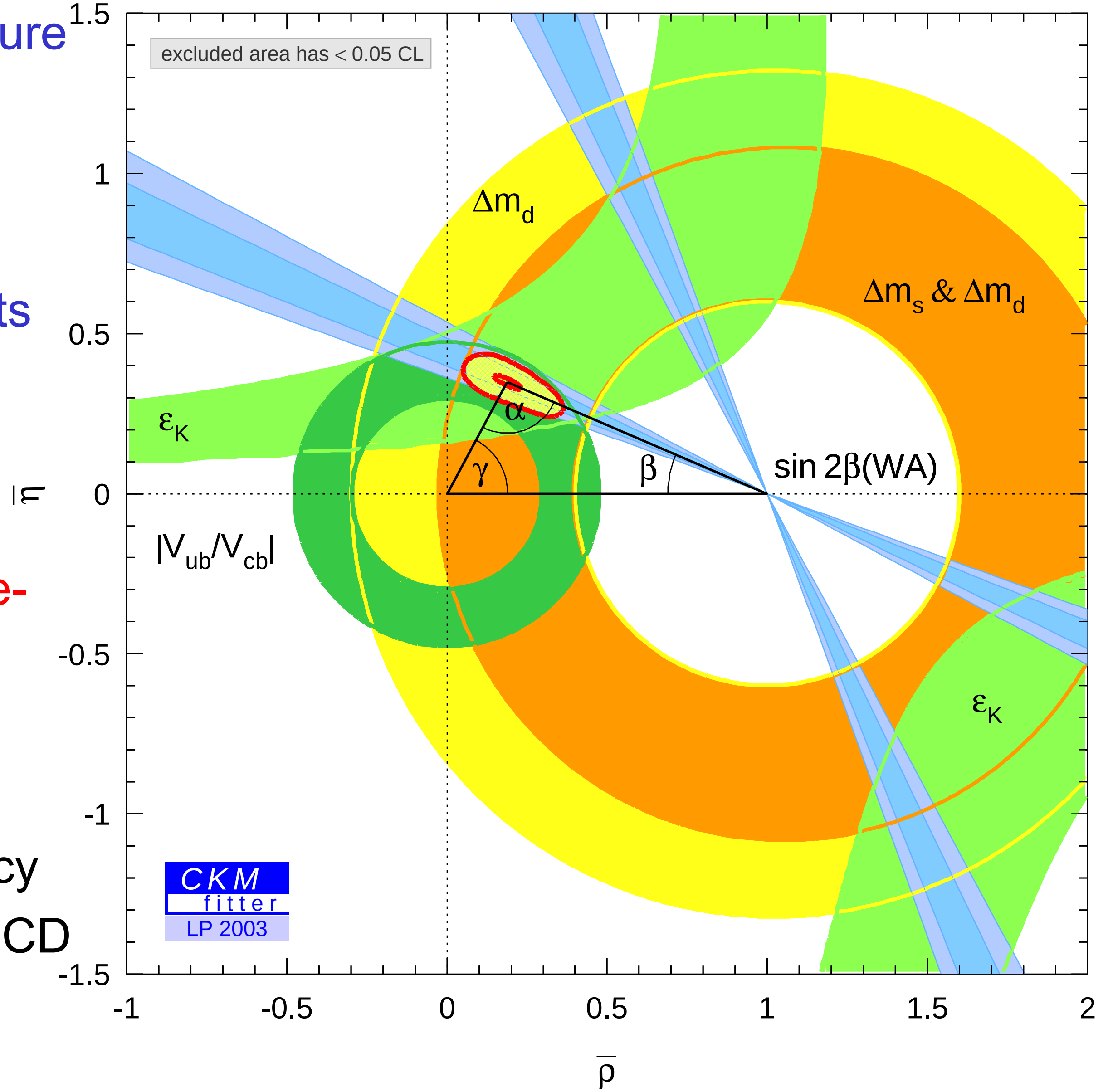
SuperBFactory (SBF)

CKM Unitarity Triangle

- Complete test of CKM picture of CP violation will require not only measurements of the angles α, β, γ, but also precise measurements of the sides

V_{cb} and V_{ub}:
semileptonic decays at e+e- machines

V_{td}:
from B^0 oscillation frequency
Needs input from Lattice QCD
and measurement of Δm_s
at hadron machines

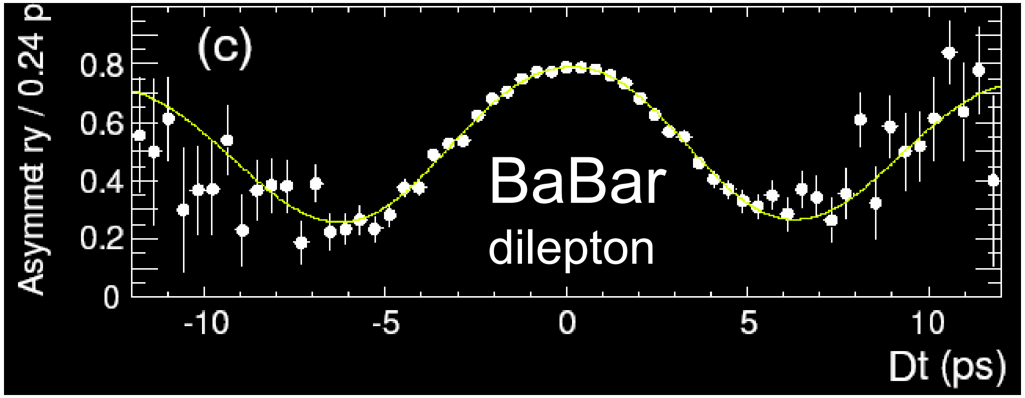


UT Sides: $|V_{td}|$

- **BaBar+Belle NOW**:

  $\Delta m_d = 0.503 \pm 0.007\ ps^{-1}$

  $\rightarrow$ uncertainty of 1.4%



- **BaBar/Belle FUTURE**:

  Assume 500 fb^{-1} for each expt

  Expect total uncertainty of ~0.0023 ps^{-1}, i.e. ~0.5%

  Completely dominated by systematic uncertainties

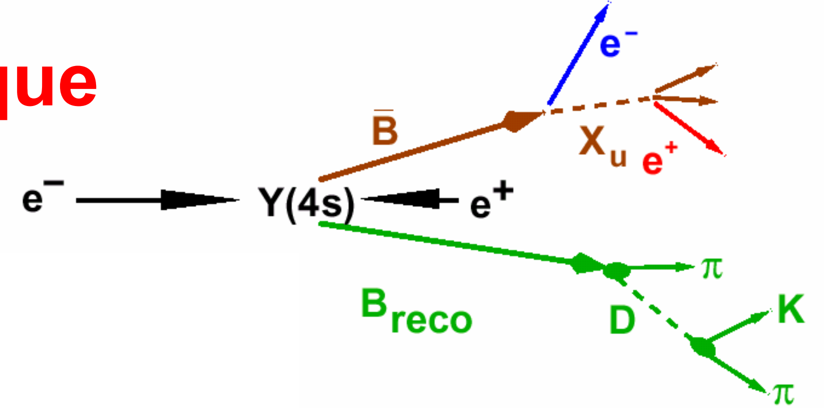
- Extraction of Vtd:

  Needs subtantial improvement from Lattice QCD ($\sigma \sim 15\%$ now)

  With a measurement of Δm_s one can reach $\sigma \sim 5\%$ (within a few years)

Note: once Δm_s is measured (1-2 yrs? from now), experimental precision in extracting Vtd is likely to be negligible compared to theory uncertainty

Vub, Vcb: B-Beam Technique



- Precise measurements of Vub and Vcb require a new approach to significantly reduce systematic (theory) uncertainties
- "B beam" technique:

  Fully reconstruct one of the two B mesons

  Reconstruct hadronic decay $B \to D^{(*)}\,(n_1\pi^{\pm}\ n_2K^{\pm}\ n_3K^0_S\ n_4\pi^0)$

  Breco efficiency = 0.3% for $B^0\bar{B}^0$ and 0.5% for B^+B^- events (BaBar)

  For 10 ab^{-1}, this yields $\sim 10^{10}\ B\bar{B} \to 15 \times 10^6\ B^0\bar{B}^0$ reco

  $25 \times 10^6\ B^+B^-$ reco

  $\to$ ~40 million B mesons recoiling against fully reconstructed B

$\Rightarrow$ Full kinematical constraints available

$\Rightarrow$ Separates decay products from the two B mesons & suppresses bkgd

$\Rightarrow$ Provides B flavor tag

B beam technique is ideal for inclusive measurements of semileptonic branching fractions $\to$ Vcb and Vub

Technique expanded with semil. decays and partially reconstructed decays

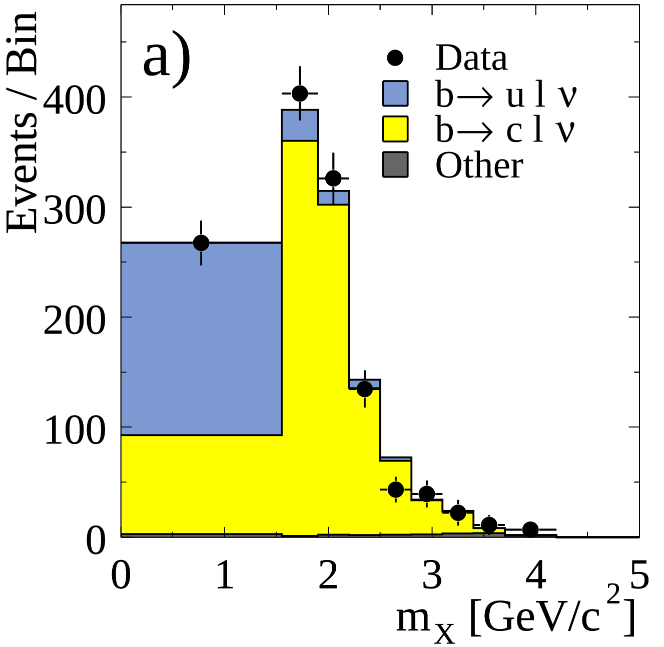
Semileptonic decays

- Inclusive semileptonic decays:

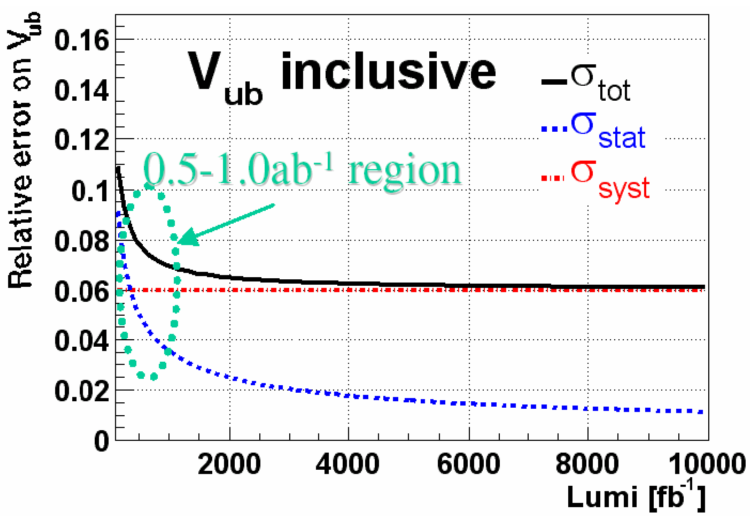
  $b \to u\, l\, \nu$ with B beam technique $\Rightarrow$ high S/B at low hadronic mass m_X

  BaBar (82 fb^{-1}):

$$|V_{ub}| = (4.62 \pm 0.28(stat) \pm 0.27(syst) \pm 0.48(theo)) \times 10^{-3}$$



Theory uncertainty can be reduced to ~5% by cutting on both m_X and q^2 but overall uncertainty saturates at 6% for lumi $\geq$ 2 ab^{-1}

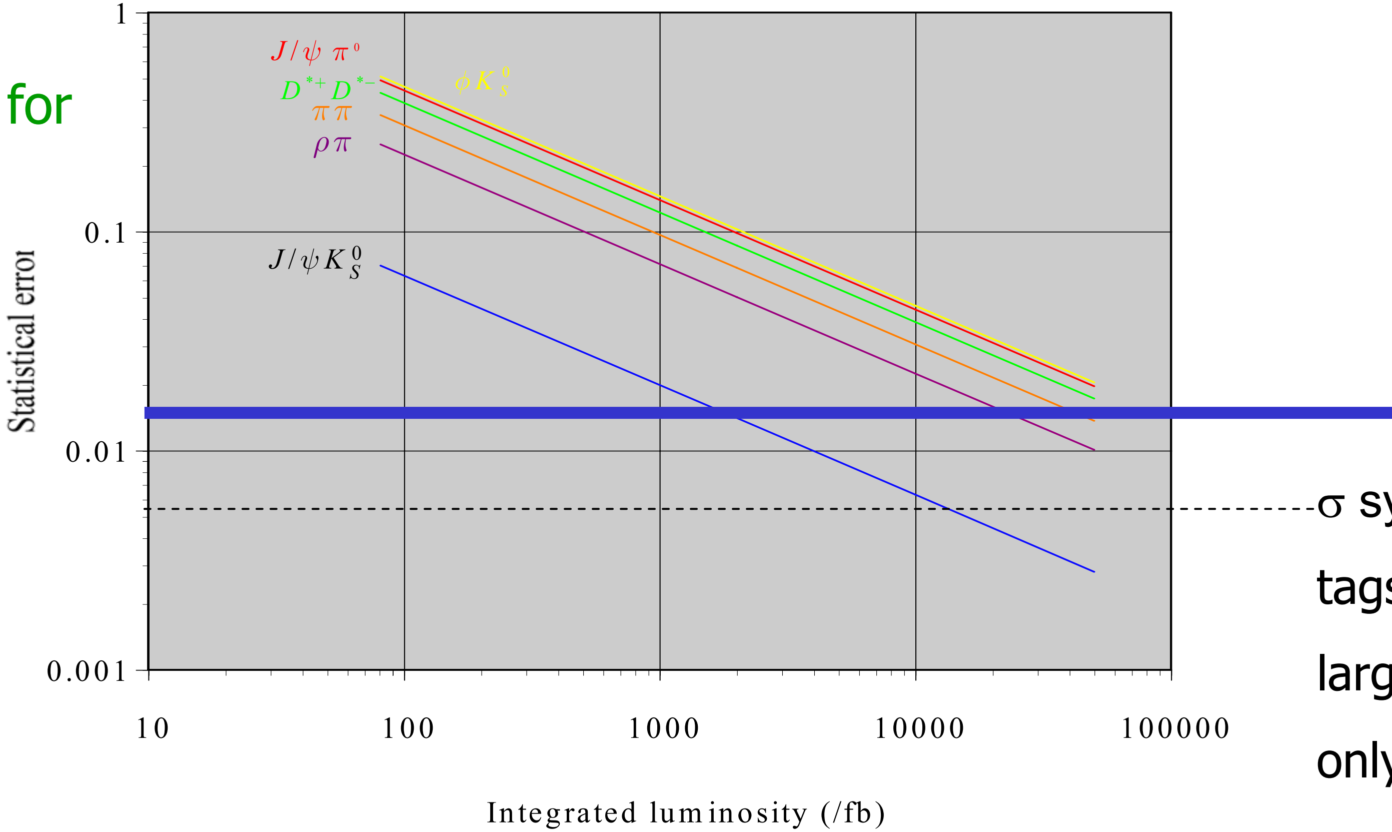


Further reduction of σ_{theory} possible if m_b and Fermi motion effects constrained from data

Measurements of UT angles

- Projections based on current analyses at BaBar
  - → Uncertainties are mostly statistical and will continue to improve as the sample size increases
  - → Only exception may be for sin(2β) in $B^0 \to J/\psi\, K^0_s$ for which it may be necessary to use only lepton tags to reduce systematic uncertainty

σ stat for sin2β meas.



σ syst

σ syst lepton tags (~70% larger σ stat if only lepton tags used)

UT angles systematics

Main systematic uncertainties in time-dependent asymmetries

1. Δt resolution: uncertainties due to vtx detector misalignment and beam spot position → reduce with improved understanding of detector
2. Dilutions: uncertainties due to difference between flavor-tagged sample and charmonium event sample → only slight improvement
3. Background: uncertainties in background composition and asymmetry → sideband data will provide much tighter constraints than currently used
4. MC correction: improves with increased MC statistics

lepton tags only
50 ab^{-1}

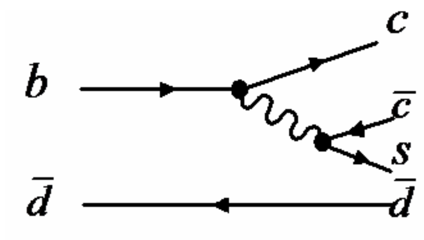
projected σ(syst) for sin 2β measurements

Component	81 fb^{-1}	0.5 ab^{-1}	2.0 ab^{-1}	10.0 ab^{-1}	leptons
Δt	0.017	0.010	0.010	0.010	0.005
Dilutions	0.012	0.010	0.010	0.010	-
Non-K_L^0 background	0.017	0.007	0.003	0.002	0.001
K_L^0 Background	0.015	0.006	0.005	0.005	-
MC correction	0.010	0.004	0.002	0.001	0.003
DCSD	0.008	0.007	0.006	0.005	-
τ_B, Δm_d	0.005	0.002	0.002	0.002	0.002
Total Sys	0.034	0.019	0.017	0.016	0.006
Stat. (golden)	0.067	0.027	0.013	0.006	0.005

Measurements of sin2β

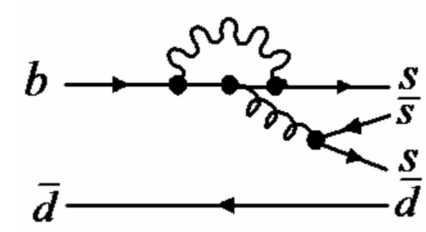
- Compare trees and loops (penguins) in clean modes

$B^0 \to J/\psi K^0_S$



$\sin(2\beta) = 0.741 \pm 0.067(stat) \pm 0.034(syst)$

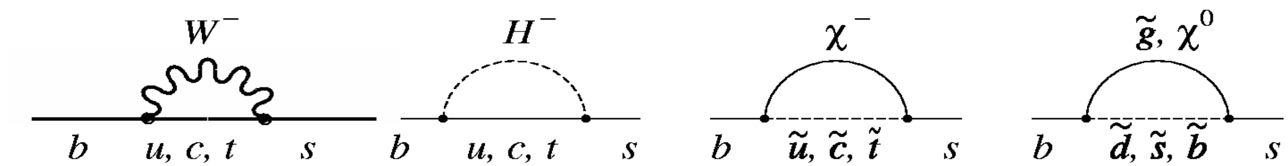
$B^0 \to \phi K^0_S$



$\sin(2\beta) = 0.45 \pm 0.43(stat) \pm 0.07(syst)$

WAvg: 0.736 ± 0.049	-0.14 ± 0.33

- $B^0 \to \phi K^0_s$ provides excellent window into new physics



& current data leaves room for new physics in $b \to s$ transitions

$\Rightarrow$ but low rates due to $BF(B^0 \to \phi K^0_s) / BF(B^0 \to J/\psi K^0_s) \sim 10^{-2}$

$\Rightarrow$ need very large data samples

$10\ ab^{-1}$: $\sigma(\sin 2\beta) < 0.01$ $[J/\psi K^0_s]$ $\sigma(\sin 2\beta) \sim 0.05$ $[\phi K^0_s]$

SuperBaBar could see $\geq 5\sigma$ deviation from $J/\psi K^0_s$ of $\geq 33\%$ with $10\ ab^{-1}$

$\geq 15\%$ with $50\ ab^{-1}$

Measurements of α (I)

- Measurement of time-dependent CP asymmetry in $B^0 \to \pi^+\pi^-$:

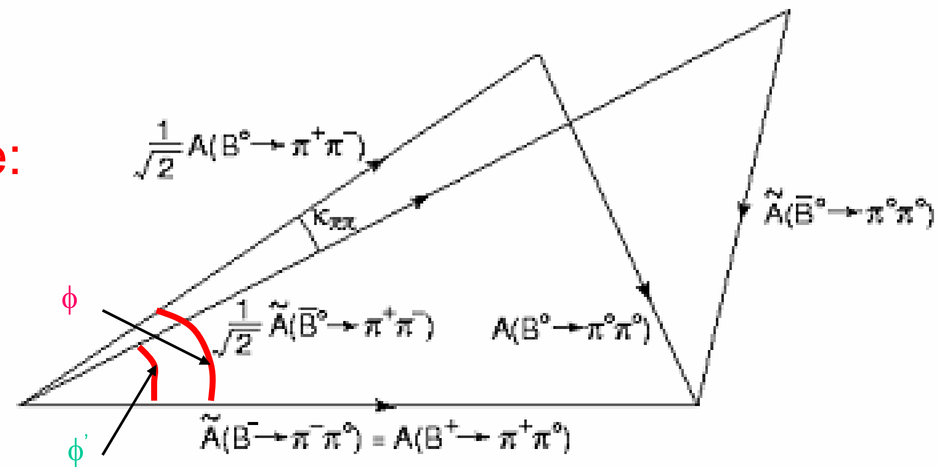
$$S_{\pi\pi} = \sqrt{1 - C_{\pi\pi}^2}\,\sin(2\alpha_{eff}) = -0.40 \pm 0.22(stat) \pm 0.03(syst)$$ BaBar (113 fb^{-1})

$\Rightarrow \sigma_{stat}(S_{\pi\pi}) = 0.023$ for 10 ab^{-1}

but penguin pollution can be sizeable:

$$2\alpha_{eff} = 2\alpha + \kappa_{\pi\pi}$$

$\Rightarrow$ need to measure $BF(B^0 \to \pi^0\pi^0)$, $BF(\overline{B}^0 \to \pi^0\pi^0)$ and determine $\kappa_{\pi\pi}$ via isospin analysis



$\to e^+e^-$ machines ideally suited for this

Measurements of α (II)

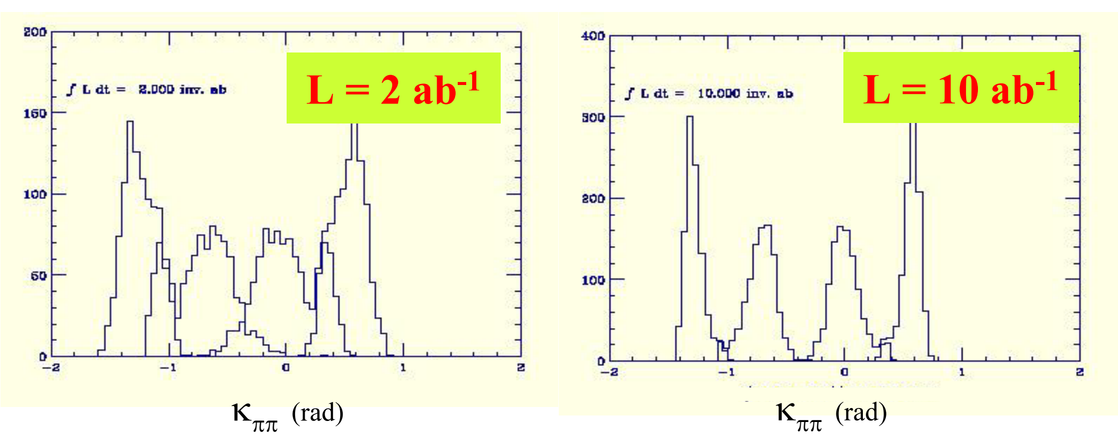
- Toy MC study of isospin analysis in $B \to \pi\pi$:

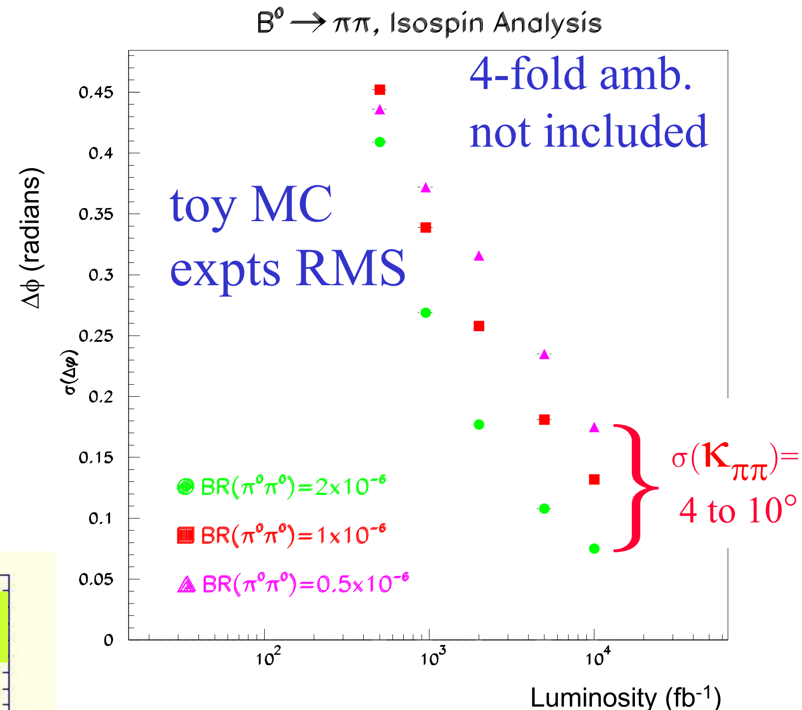
  Several choices of BF were studied

  For example, results using

  $BF(B^0 \to \pi^0\pi^0) = 1.5 \times 10^{-6}$

  $BF(\overline{B}^0 \to \pi^0\pi^0) = 0.5 \times 10^{-6}$

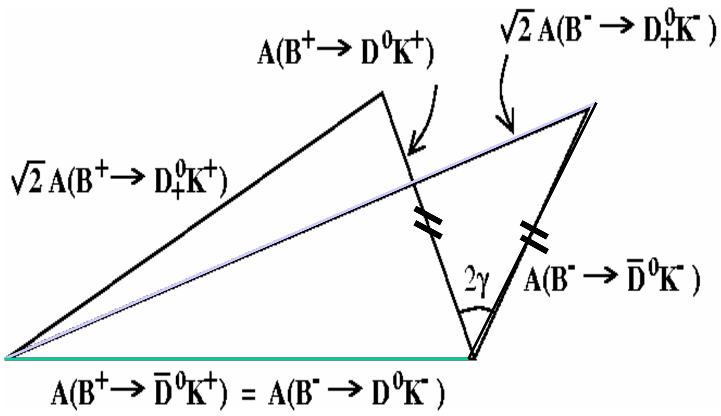




4-fold ambiguity!

$\Rightarrow$ really need Super B Factory luminosities for precise and clean determination of α!

Measurements of γ (I)



Gronau-Wyler-London method: $B \to D^0 K$
with D^0 decays to CP even and odd final states

$$\sqrt{2}\,A(B^- \to D^0_{\pm} K^-) = A(B^- \to D^0 K^-) + A(B^- \to \bar{D}^0 K^-)$$

Measure:

$$\frac{\Gamma(B^- \to D_+ K)}{\Gamma(B^- \to D_0 K)} = f^-_+(\gamma, \Delta\delta, r)$$

$$\frac{\Gamma(B^- \to D_- K)}{\Gamma(B^- \to D_0 K)} = f^-_-$$

$$\frac{\Gamma(B^+ \to D_- K)}{\Gamma(B^- \to D_0 K)} = f^+_-$$

$$\frac{\Gamma(B^+ \to D_+ K)}{\Gamma(B^- \to D_0 K)} = f^+_+$$

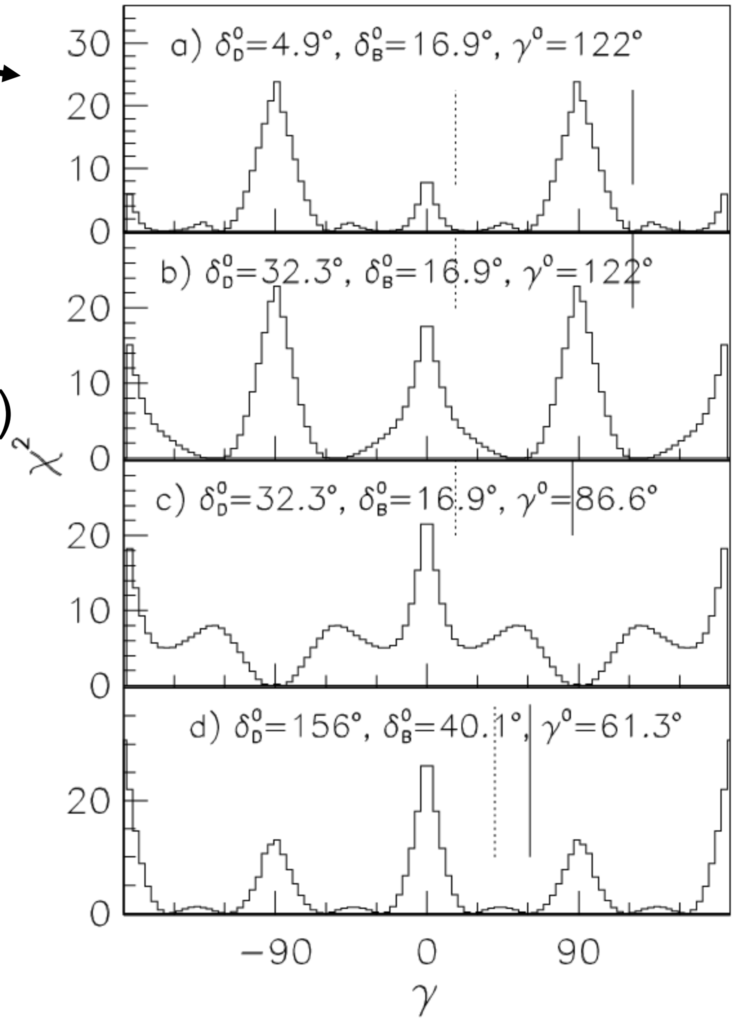
$$r \equiv \left|\frac{A(B^- \to \bar{D}_0 K^-)}{A(B^- \to D_0 K^-)}\right| = O(0.1)$$

2 ab^{-1}		
r	$\sin^2\gamma$	γ
0.3	0.72 ± 0.13	$(58.1 \pm 9.1)^{o}$
0.2	0.73 ± 0.25	$(59^{+23}_{-15})^{o}$
0.1	unreliable	unreliable

- Crucially depends on r (breaks down for $r < 0.1$?)
- 8-fold ambiguity spoils the extraction of γ
- But $A_{CP} = 2r \sin\Delta\delta \sin\gamma$ **is accessible**:
  $\sigma(A_{CP}) \sim$ **0.03** with 2 ab^{-1}

Measurements of γ (II)

- 600 fb^{-1}: toy MC study (A.Soffer)
  Combines GWL and ADS methods
  and uses all $D^{(*)}K^{(*)}$ final states
  $\rightarrow$ 8-fold ambiguity!



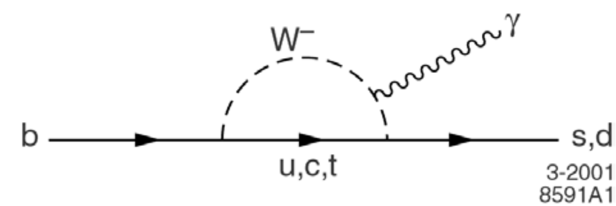
- 10 ab^{-1}: ambiguities can be resolved once sensitivity is high enough (at Super B Factory)

  Too early to give firm projection
  but expect $B \rightarrow D^{(*)}K^{(*)}$ studies to determine γ with a statistical uncertainty of 1° to 2.5° (for 10 ab^{-1})

- **sin(2β+γ)** from $B^0 \rightarrow D^{(*)} \pi / \rho / a_1 / K^0_s$
  main uncertainty in the ratio between "Vub" and "Vcb" amplitudes
  $\Rightarrow$ expect uncertainty of 0.05 for 10 ab^{-1}

$$r(D^{(*)}\pi) \equiv r_{(*)} = \left| \frac{A(\overline{B}^0 \to D^{(*)-}\pi^+)}{A(B^0 \to D^{(*)-}\pi^+)} \right| \approx 0.02$$

Radiative Penguin Decays (I)



- <u>UT side measurement with **exclusive** decays</u>:

Measure BF($B \to \rho\gamma$) ~ 1 x 10^{-6} to extract $|V_{td} / V_{ts}|$ via

$$\frac{B \to \rho\gamma}{B \to K^*\gamma} = |\frac{V_{td}}{V_{ts}}|^2 \left(\frac{1 - m_\rho^2/M_B^2}{1 - m_{K^*}^2/M_B^2}\right)^3 \zeta^2 [1 + \Delta R]$$

$\to$ BaBar 500 fb^{-1}: Uncertainty in $|V_{td} / V_{ts}|$ of 10-15% [σ(theory) ~ 15%]

Complementary to $\Delta m_s / \Delta m_d$ (but remember sin 2β in ϕK^0_s !)

$\to \geq$ 10 fb^{-1}: Limited by ~ 5% systematic uncertainty + theory ~ 10%?

- <u>UT side measurement with **inclusive** decays</u>:

BF($B \to X_d \gamma$) / BF ($B \to X_s \gamma$) yields cleaner $|V_{td} / V_{ts}|$ [σ(theory) <10%?]

but inclusive $B \to X_d \gamma$ decays are very difficult experimentally

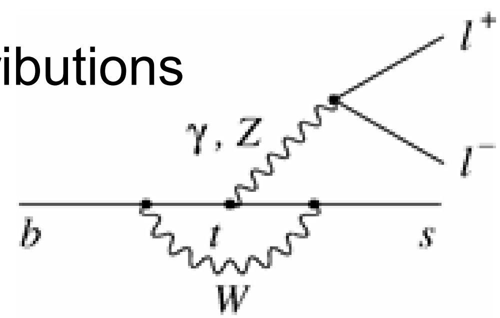
may be possible with >10 ab^{-1} and B-beam technique

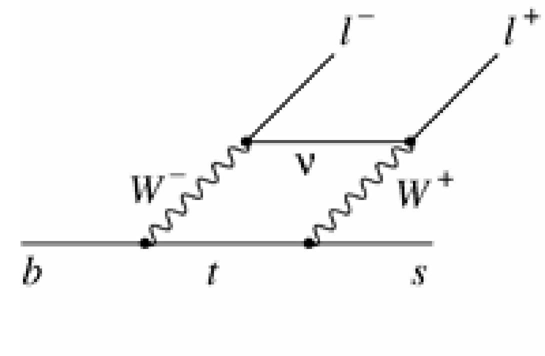
Study with lepton tag (to suppress udsc bkgd) yields

σ_{stat} on $|V_{td} / V_{ts}|$ of 15-20% for 10 ab^{-1} and 10-15% for 50 ab^{-1}

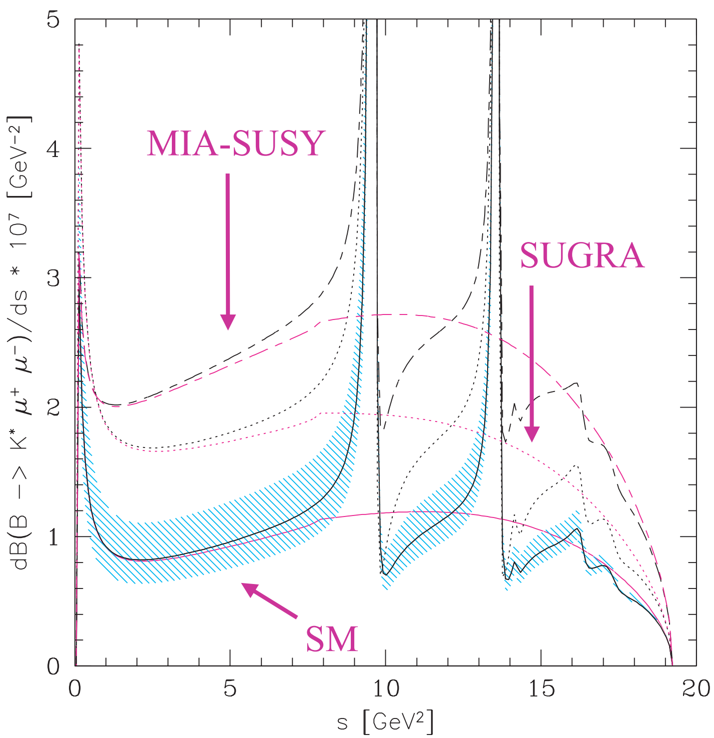
Rare semileptonic decays (I)

- Decays involving b $\rightarrow$ s l^+ l^- transitions are sensitive to new physics contributions

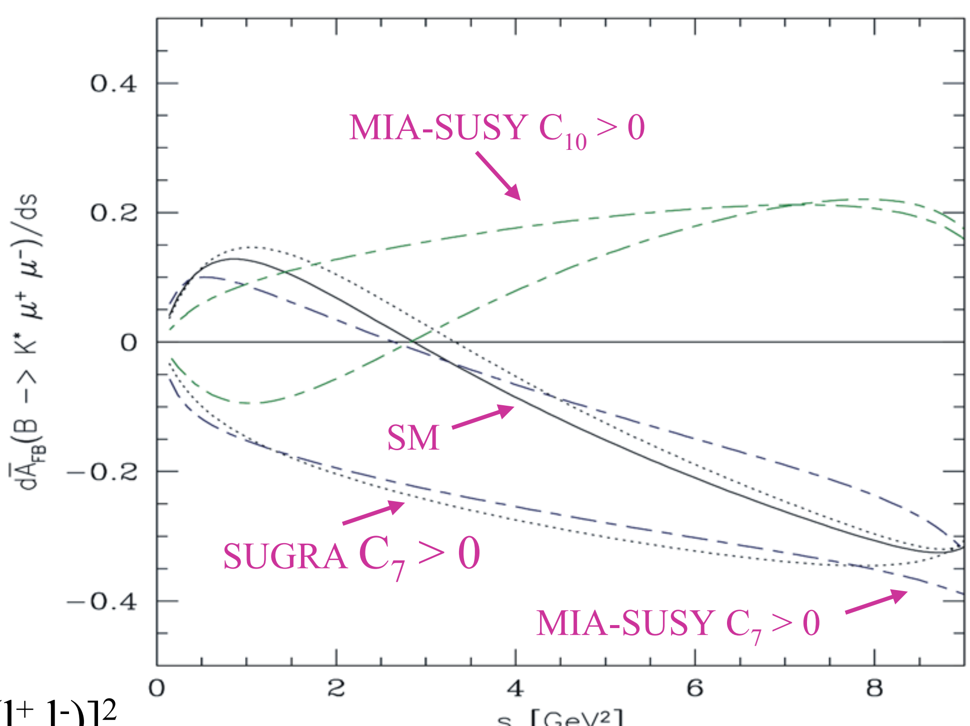




B $\rightarrow$ K* μ^+ μ^- decay rate



B $\rightarrow$ K* μ^+ μ^- forward-backward asymmetry

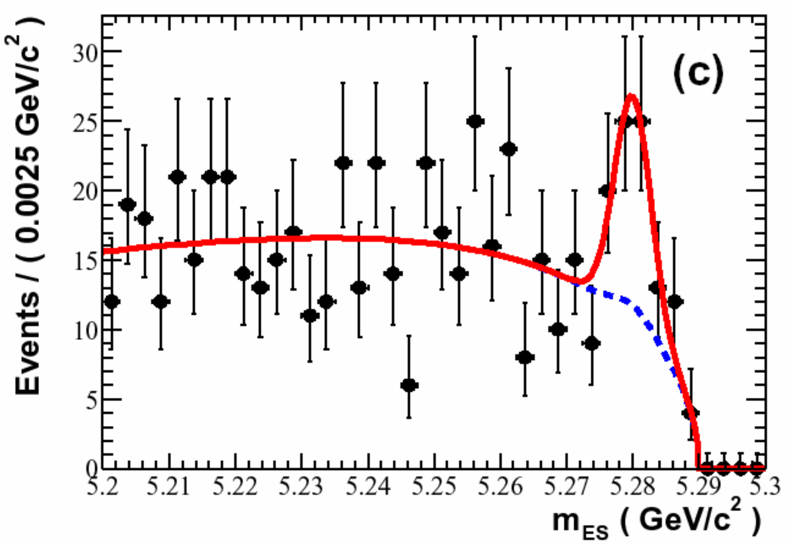


$[M(l^+ l^-)]^2$

Rare semileptonic decays (II)

BaBar 82 fb^{-1}

- Semi-inclusive analysis: $B \to X_s l^+ l^-$ decays



BF theory σ ~15% for all $\hat{s} = m_{ll}^2/m_b^2$

[6% scale only T.Hurth] (11% U. Haisch)

for $0.05 < \hat{s} < 0.25$

Expect ~350 signal events for 0.5 fb^{-1}

~7000 signal events for 10 ab^{-1}

Estimate for BF measurement uncertainties:

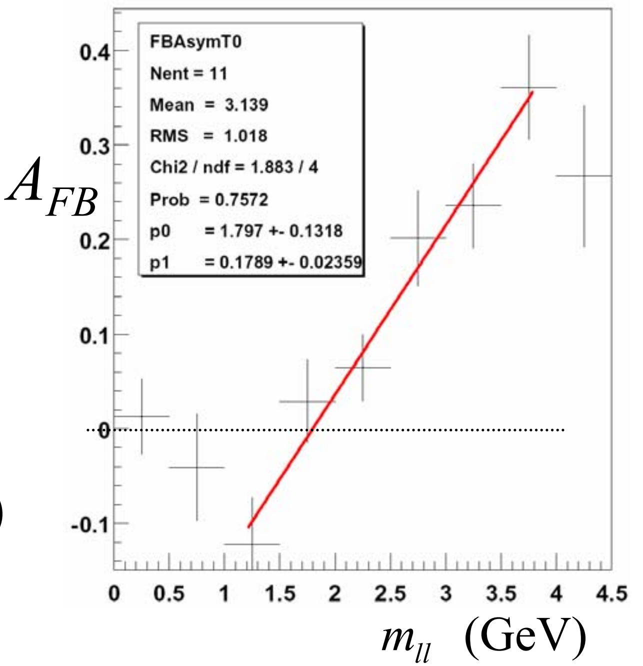
Signal yield **$X_s e^+e^- + X_s \mu^+\mu^-$**	500 fb^{-1}	1000 fb^{-1}	10 ab^{-1}	50 ab^{-1}
All $\hat{s}$ (exc. J/Ψ veto)	σ_{stat} = 10% 7% < σ_{syst} < 14%	σ_{stat} = 7% 5% < σ_{syst} < 14%	σ_{stat} = 2.1% 1.5% < σ_{syst} < 6%?	σ_{stat} = 1.0% 0.7% < σ_{syst} < 6%?
$0.05 < \hat{s} < 0.25$	σ_{stat} = 16%	σ_{stat} = 11%	σ_{stat} = 3.4%	σ_{stat} = 1.5%
$\hat{s} > 0.65$	σ_{stat} = 22%	σ_{stat} = 15%	σ_{stat} = 5.0%	σ_{stat} = 2.3%

$\Rightarrow$ Need Super B Factory to reach (future) theory uncertainty at low $\hat{s}$

Rare semileptonic decays (III)

- <u>Forward-backward asymmetry</u> in $B \to X_s\, l^+ l^-$

pure signal 10 ab^{-1}



In dilepton rest frame:

N_F = # l^+ along b-quark direction

N_B = # l^+ opposite b-quark dir.

$$A_{FB} = \frac{N_F - N_B}{N_F + N_B}$$

Predicted zero point of the asymmetry:

$A_{FB} = 0$ for $\hat{s} = \hat{s}_0 = 0.162 \pm 0.008$ (NNLL)

Estimate with 10 ab^{-1} sample (after bkg subtraction)

$\to \hat{s}_0 \simeq 0.14 \pm 0.04$(stat)

Estimate for asymmetry measurement (σ_{stat} only):

A_{FB} $X_s e^+e^- + X_s \mu^+\mu^-$	500 fb^{-1}	1000 fb^{-1}	10 ab^{-1}	50 ab^{-1}
$\hat{s} < \hat{s}_0$	-0.02 ± 0.17	-0.02 ± 0.12	-0.017 ± 0.039	-0.017 ± 0.017
$\hat{s} > \hat{s}_0$	0.17 ± 0.22	0.17 ± 0.16	0.173 ± 0.050	0.173 ± 0.022

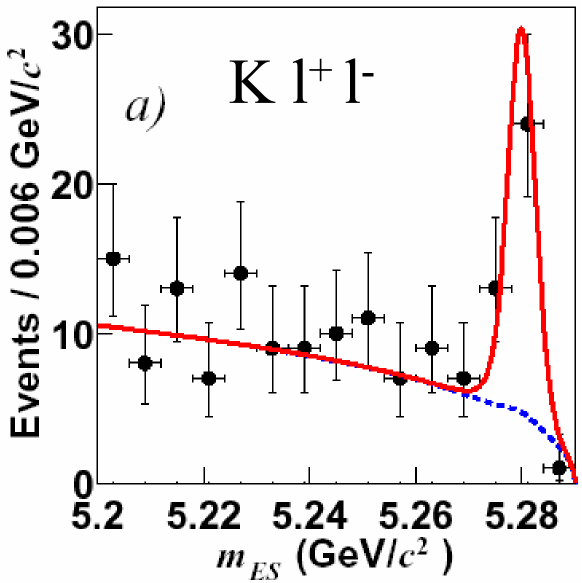
$\Rightarrow A_{FB}$ clearly needs high-luminosity B Factory

Rare semileptonic decays (IV)

BaBar 113 fb^{-1}

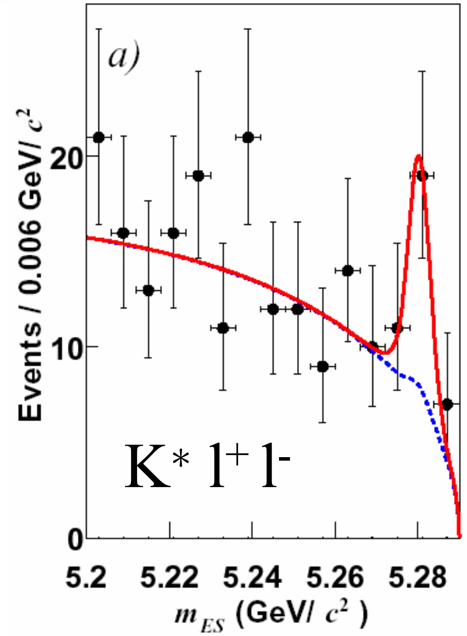
- Exclusive analysis: $B \to K^{(*)} l^+ l^-$ decays

Based on current BaBar analysis, expect # signal events for 10 ab^{-1} of 2000 for $K e^+ e^-$ and 1500 for $K \mu^+ \mu^-$ 2600 for $K^* e^+ e^-$ and 1700 for $K^* \mu^+ \mu^-$



Current theory uncertainty in BF is ~34%

$\Rightarrow$ main interest is in the forward-backward asymmetry (coming soon…)



Other Measurements

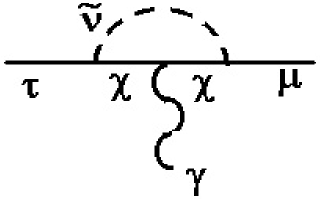
- Many other physics topics become very interesting at Super B Factory luminosities, for example:

1. **Rare B decay processes with missing particles**: $B \rightarrow \tau\ \nu$, $K\nu\nu$, $\tau\tau$, $\nu\nu$ $\rightarrow$ method like full (or partial) B-beam technique is crucial

2. **Radiative penguin B decays**: reduced theory dependence in BF measurement of inclusive $b \rightarrow s\ \gamma$ (full or partial B-beam technique)
   σ_{tot} ~7% (0.5 ab^{-1}) and ~2% (10 ab^{-1})
   Interesting level of sensitivity for A_{CP} measurements

3. **Charm physics**: huge samples for D^0 mixing (σ_x~0.001) and rare D decay studies

4. **Tau physics**: sensitivity for lepton-number violation in $\tau \rightarrow \mu\ \gamma$ (expect 5σ sensitivity down to BF of 1×10^{-7})



5. Other ideas…

Super B Factory Parameters

- How do we get a factor of 100 improvement in luminosity?

	Super B Factory		B Factory	
Beam	e+	e-	e-	e+
E (GeV)	8.0	3.5	9.0	3.1
#bunches	7000		800	
lifetime (min)	7	5	200	
Current (A)	10.3	23.5	1.0	1.8
β^* (mm)	x=150/y=1.5		x=450/y=10	
Emittance (nm)	x= 44/y=0.44		40/2.5	
Beam spot (μm)	x= 81/y=0.8		x= 147/y=5	
Tune shift	0.10		0.07	

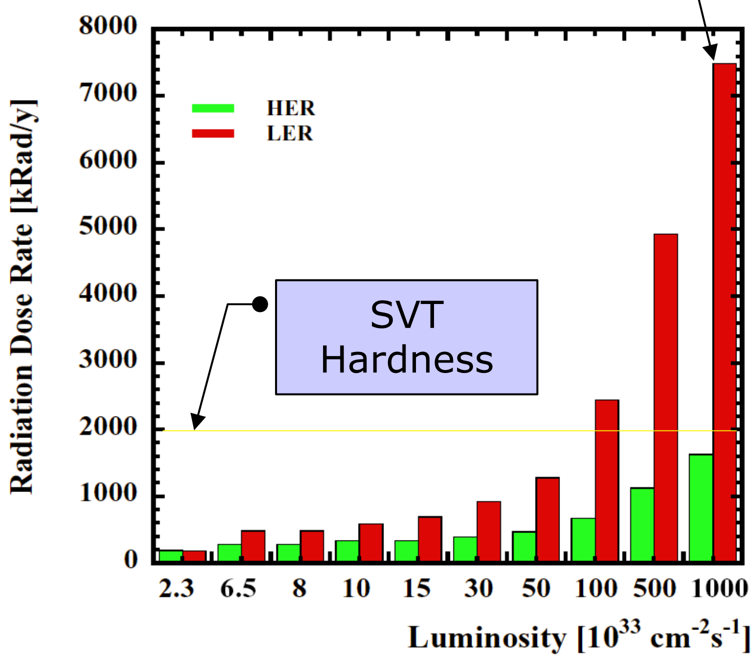
Super B Factory Environment

- Reaching 10^{36} implies that a series of issues have to be faced:
  - ▶ Higher beam currents, stronger focusing, *continuous injection*
  - ▶ Increased background and higher rates for detector
    - ⇒ Radiation damage
    - ⇒ High occupancy

⇒ NEED NEW DETECTOR

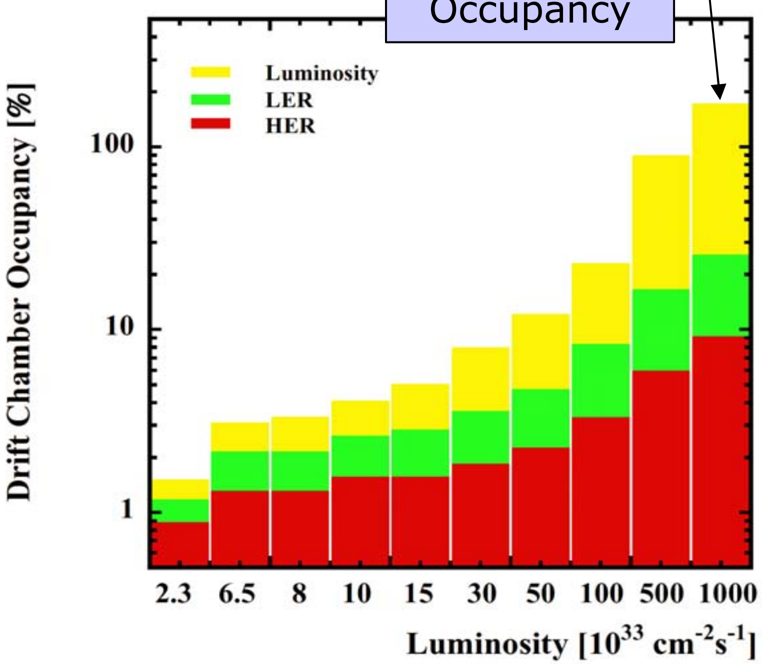
SVT Dose

7 Mrad/yr



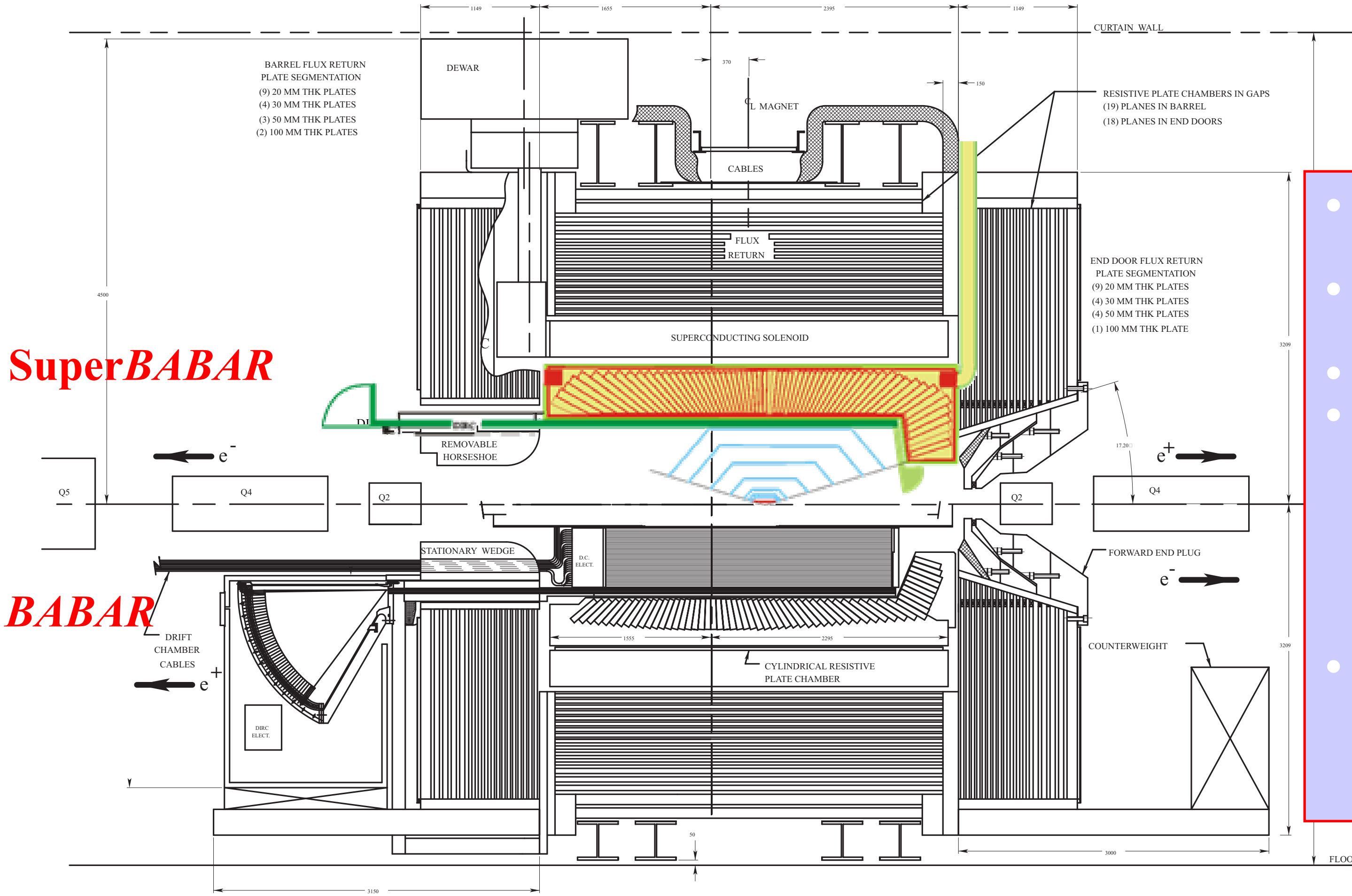
DCH Occupancy

>100% Occupancy



Super BaBar Detector

- Possible upgrade of BaBar detector:



- IFR upgraded (ongoing)
- Remove SVT,DCH, EMC, DIRC
- New EMC – liquid Xe
- New tracker
  - Two inner pixel layers
  - Seven(?) thin double-sided Si-strip arch layers
- New DIRC(s) with compact readout

Emphasis on high segmentation, fast integration time, radiation hardness

Detector Issues

- Super BaBar detector designed to have sufficient granularity to deal with the high occupancy

  However, some issues need investigating…
  - tracking efficiency and fake tracks
  - calorimeter resolution, fake photons, ability to veto pi0, etc…
  - particle ID performance
  - etc…

  $\rightarrow$ *studies yet to be performed*

- Some *detector R&D is needed* for:
  - thin (100 μm) Si detector and low-power electronics
  - small-cell drift chamber in high radiation environment
  - focusing DIRC with pixelated PMT
  - choice of EM calorimeter: liquid Xe vs. (fast) crystals
  - technology for muon ID

Summary

A high-luminosity B Factory promises samples of up to 10^{11} B mesons (5 yrs)

Huge range of physics but motivation is discovery/ measurement of new physics via **CPV and rare decays**

(many extremely interesting topics and analyses not shown!)

	BaBar (2007)		SuperBaBar (2012)	
Lumi	600 fb^{-1}		10 ab^{-1}	
	σ_{stat}	σ_{syst}	σ_{stat}	σ_{syst}
$\delta\ \sin 2\alpha_{eff}\ (\pi\pi)$	0.095	0.02-0.03	0.023	0.01-0.02(?)
$\delta\ \sin 2\alpha_{eff}\ (\rho\pi)$	0.078	0.02-0.03	0.019	0.01-0.02
$BF(B^0 \rightarrow \pi^0\pi^0)$	12%	<10%	3%	?
$\delta\ \gamma\ (B_d \rightarrow DK)$			1.0^o-2.5^o	
$\delta\ \sin(2\beta+\gamma)$	0.2		0.05	
$\delta\ \sin(2\beta)\ \phi K$	0.19	0.03	0.046	0.01-0.02
$BF(B \rightarrow X_s l^+ l^-)$	10%	~10%	2%	~4%

Current knowledge (subject to change…)

Additional Slides

BTeV / Super B Comparison (D.Hitlin)

Mode	*B*TeV		Super *B*	
	Yield	Tagged	Yield	Tagged
$B_s \rightarrow J/\psi\,\eta^{(\prime)}$	12650	1645	-	-
$B^- \rightarrow \phi K^-$	11000	11000	14000	14000
$B^0 \rightarrow \phi K_s$	2000	200	5000	1500
$B^0 \rightarrow K^* \mu^+ \mu^-$	2530	2530	~1000	~1000
$B_s \rightarrow \mu^+ \mu^-$	6	0.7	-	
$B^0 \rightarrow \mu^+ \mu^-$	1	0.1	0	-
$D^{*+} \rightarrow \pi^+ D^0,\ D^0 \rightarrow K^- \pi^+$	$\sim 10^8$	$\sim 10^8$	1.6×10^7	1.6×10^7

1-year yields

BTeV / Super B Comparison (D.Hitlin)

- Number of flavor tagged $B^0 \rightarrow \pi^+ \pi^-$ (B=0.45x10^{-5})

α

	$\mathcal{L}$ (cm^{-2}s^{-1})	σ	$B^0/10^7$s	ε	εD^2	Tagged events
Super B	10^{36}	1.1 nb	1.1×10^{10}	0.45	0.26	5600
BTeV	2×10^{32}	100 μb	1.5×10^{11}	0.021	0.1	1426

- Number of $B^- \rightarrow D^0 K^-$ (Full product B=1.7x10^{-7})

γ

	$\mathcal{L}$ (cm^{-2}s^{-1})	σ	$B^0/10^7$s	ε	Events
Super B	10^{36}	1.1 nb	1.1×10^{10}	0.4	500
BTeV	2×10^{32}	100μb	1.5×10^{11}	0.007	176

- B_s , B_c and Λ_b studies are not done at $\Upsilon(4S)$ e^+e^- machines

Snowmass 2001 E2 Group Comparison

	BTeV 10^7s	LHCb 10^7s	*BABAR* Belle (2005)	10^{35} 10^7s	10^{36} 10^7s	
$\sin 2\beta$	0.011	0.02	0.037	0.026	0.008	Equal
$\sin 2\alpha$	0.05	0.05	0.14	0.1	0.032	Equal
$\gamma\,[B_s(D_sK)]$	$\sim 7^o$					Had
$\gamma\,[B(DK)]$	$\sim 2^o$		$\sim 20^o$		1-2.5^o	Equal
$\sin 2\chi$	0.023	0.04	-	-	-	Had
$BR(B \to \pi^o\pi^o)$	-	-	$\sim$20%	14 %	6%	e^+e^-
V_{ub}	-	-	$\sim$2.3%	$\sim$1% (sys)	$\sim$1% (sys)	e^+e^-

UT Angles: Impact of SUSY

Ratio of amplitudes in SM

SM phase

Ratio of MSSM/SM amplitudes

MSSM phase

Incl.	Excl.	ϕ^D_{SM}	r_{SM}	ϕ^D_{SUSY}	r_{250}	r_{500}
$b \to c\bar{c}s$	$B \to J/\psi K_S$	0	–	ϕ_{23}	$0.03 - 0.1$	$0.008 - 0.04$
$b \to s\bar{s}s$	$B \to \phi K_S$	0	–	ϕ_{23}	$0.4 - 0.7$	$0.09 - 0.2$
$b \to u\bar{u}s$		Tree γ				
	$B \to \pi^0 K_S$		$0.009 - 0.08$	ϕ_{23}	$0.4 - 0.7$	$0.09 - 0.2$
$b \to d\bar{d}s$		Penguin 0				
$b \to c\bar{u}d$		0				
	$B \to D^0_{CP}\pi^0$		0.02	–	–	–
$b \to u\bar{c}d$		γ				
	$B \to D^+D^-$	Tree 0	$0.03 - 0.3$		$0.007 - 0.02$	$0.002 - 0.006$
$b \to c\bar{c}d$				ϕ_{13}		
	$B \to J/\psi\pi^0$	Penguin β	$0.04 - 0.3$		$0.007 - 0.03$	$0.002 - 0.008$
	$B \to \phi\pi^0$	Penguin β	–		$0.06 - 0.1$	$0.01 - 0.03$
$b \to s\bar{s}d$				ϕ_{13}		
	$B \to K^0\bar{K}^0$	u-Penguin γ	$0 - 0.07$		$0.08 - 0.2$	$0.02 - 0.06$
$b \to u\bar{u}d$	$B \to \pi^+\pi^-$	Tree γ	$0.09 - 0.9$	ϕ_{13}	$0.02 - 0.8$	$0.005 - 0.2$
$b \to d\bar{d}d$	$B \to \pi^0\pi^0$	Penguin β	$0.6 - 6$	ϕ_{13}	$0.06 - 0.4$	$0.02 - 0.1$
	$B \to K^+K^-$	Tree γ	$0.2 - 0.4$		$0.04 - 0.1$	$0.01 - 0.03$
$b\bar{d} \to q\bar{q}$				ϕ_{13}		
	$B \to D^0\bar{D}^0$	Penguin β	only β		$0.01 - 0.03$	$0.003 - 0.006$

Precision on the determination of UT sides

- Snowmass 2001 projections:

	Analysis	σ_{stat} (2007)%	σ_{stat} (2012)%	σ_{sys} (2012)%	σ_{th} (>2010) %
V_{cb}	$D^{(*,**)}l\nu$	0.4	0.1	1	1
	$b \to cl\nu$	1	0.5	0.5	5
V_{ub}	$b \to ul\nu$	3	0.7	2.5	5
	$B \to X_u l\nu$	9	2	2.5	
V_{td}	$\Delta M_d{}^*$	0.2	0.05	0.5	5
V_{ub}, V_{td}	$B \to \tau\nu$		seen?!		

* best approach with $\Delta m_s/\Delta m_d$ but could also check with $\rho\,\gamma$ / $K^*\,\gamma$